Human-Centered Intelligent Systems for Mission Operations

Jane T. Malin

and team

Intelligent Systems/Human Centered Systems
Project Review 10/24/02

Team Members

- Analysis and design methods
  - Carroll Thronesbery, Kathy Johnson, David Overland
- System management agents and simulation
  - Debra Schreckenghost, Land Fleming and Lou Flores
- Information assistant agents and team tools
  - Arthur Molin, Grace Lei, Dan Smith, Patrick Oliver, David Overland
- Team tools and mission spin-offs
  - David Overland, Gene Peter and Kevin Taylor (DV) and Kathy Johnson (SD – SMART project for SURGEON/BME)

Project Objectives

- Cooperating intelligent agents for future heterogeneous distributed multi-tasking teams
  - Intelligent Systems Management Agents (ISMAs) designed for multi-agent teamwork
- New human-centered methods for prototyping intelligent agents and their operations infrastructure

FY01 Findings

- Need additional type of agent to support operations teams
  - Information management agents: Intelligent Briefing and Response Assistants (IBRAs)
    - Customizable, simpler, using same tools as operations team
- Importance of infrastructure and work integration
  - Need suite of information handling tools for agents and operations teams,
  - Support incremental agent development

FY01 Operations Concept: Space and Ground Periodic Cognizance/orienting with Support for Team Response

Vehicle/crew

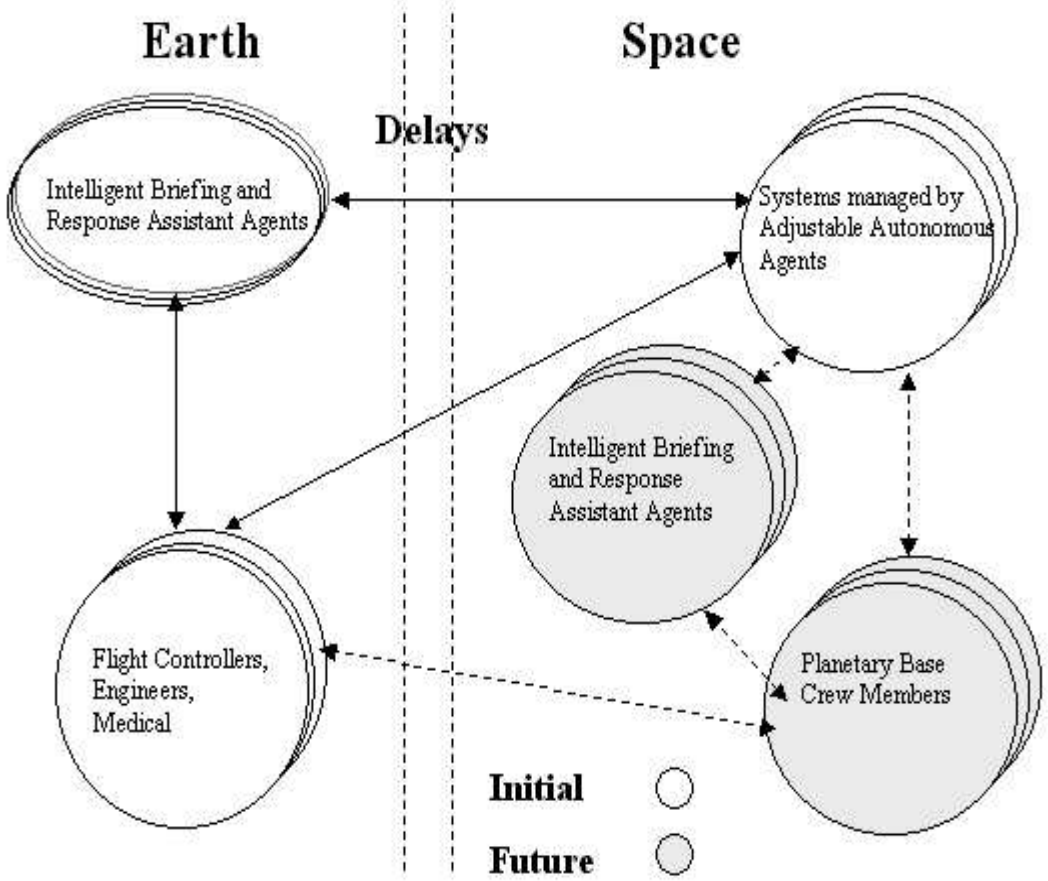
- Increased level of crew/vehicle autonomy
- Includes both crew and ISMA software
- Software does the vigilant monitoring
- Crew manages by exception

Multi-discipline officers

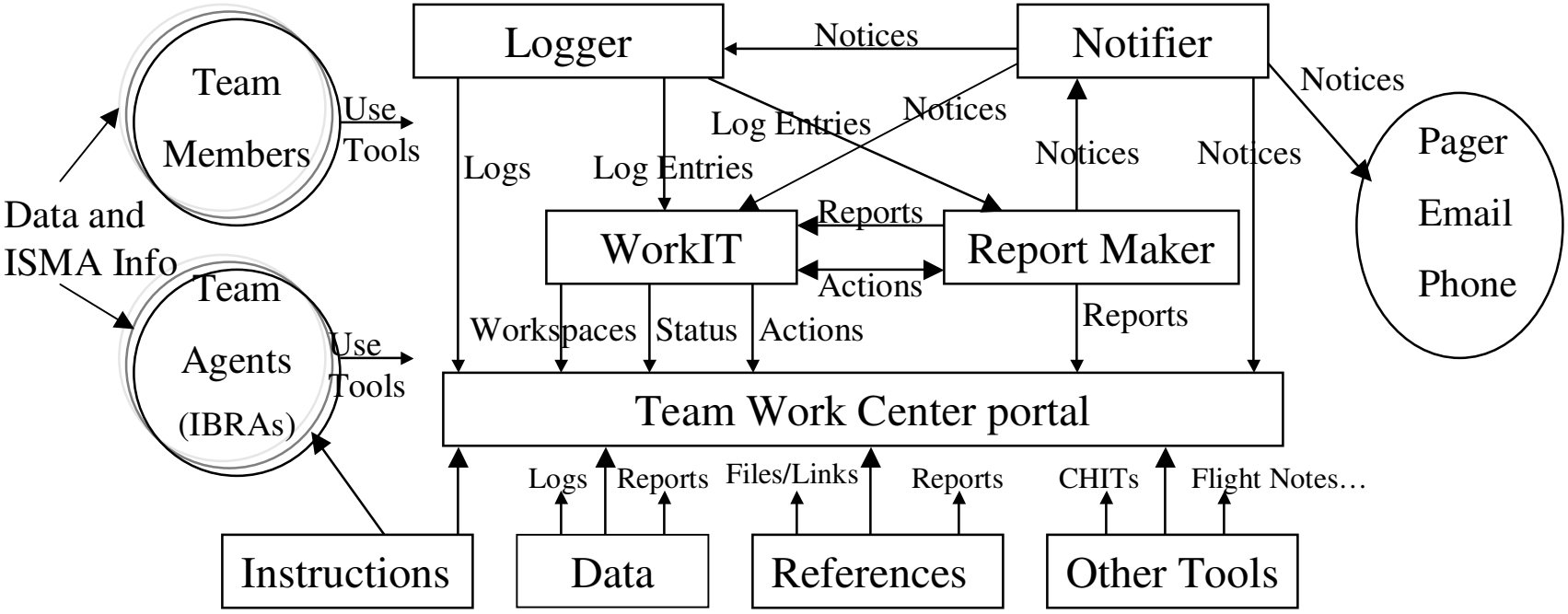
- Includes both person and IBRA software
- Vigilant monitoring, notify specialists of problems
- Works shifts in mission control center (MCC) only

Discipline specialists

- Flight controller functions
- Intermittent monitoring
- Works in MCC and office
- Includes both person and IBRA software
- Responsibilities beyond current mission



FY01 Linked Tools Concept:
Used by Agents and Team Members

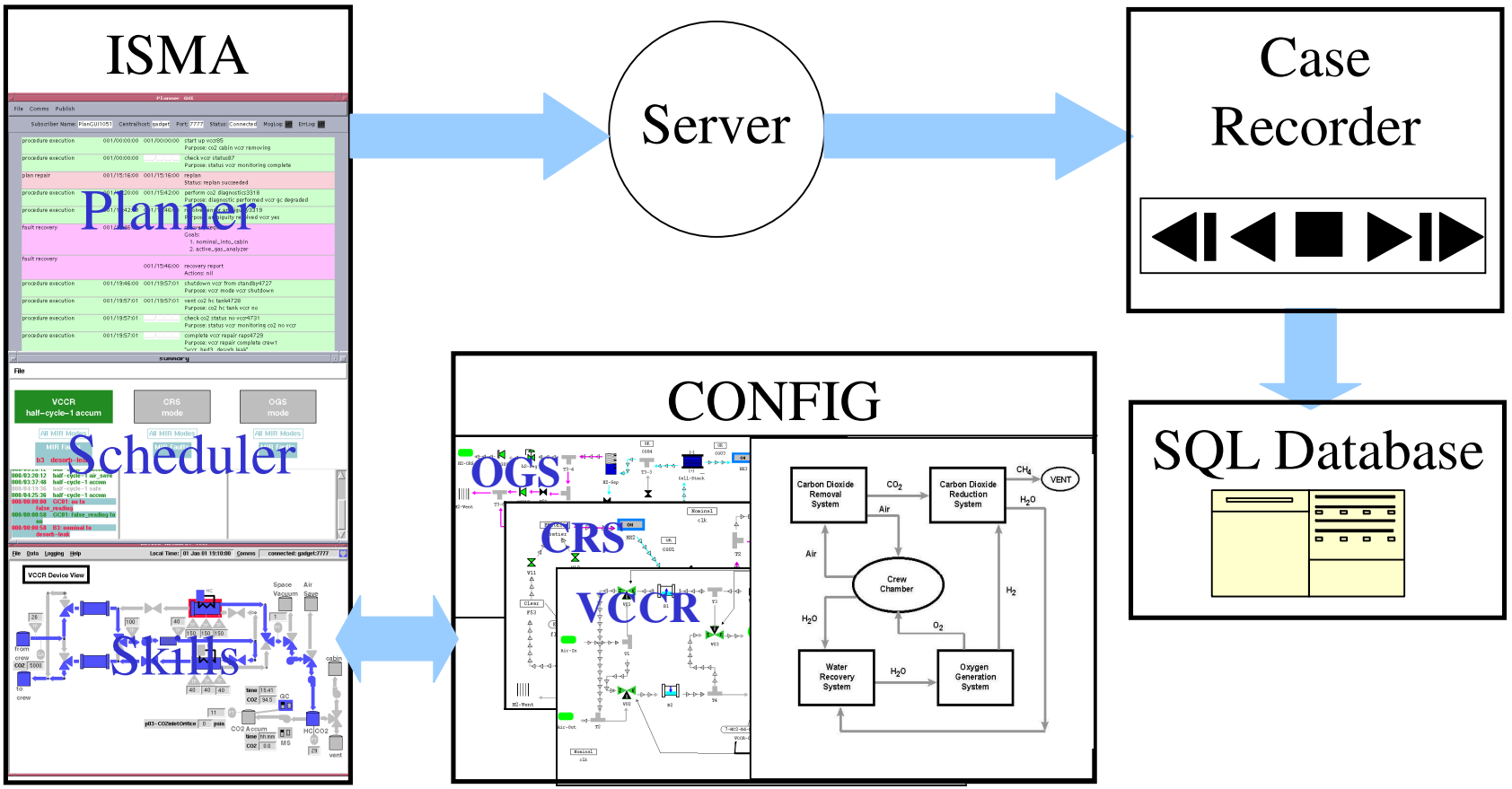


A team member enters content once, for use in multiple places

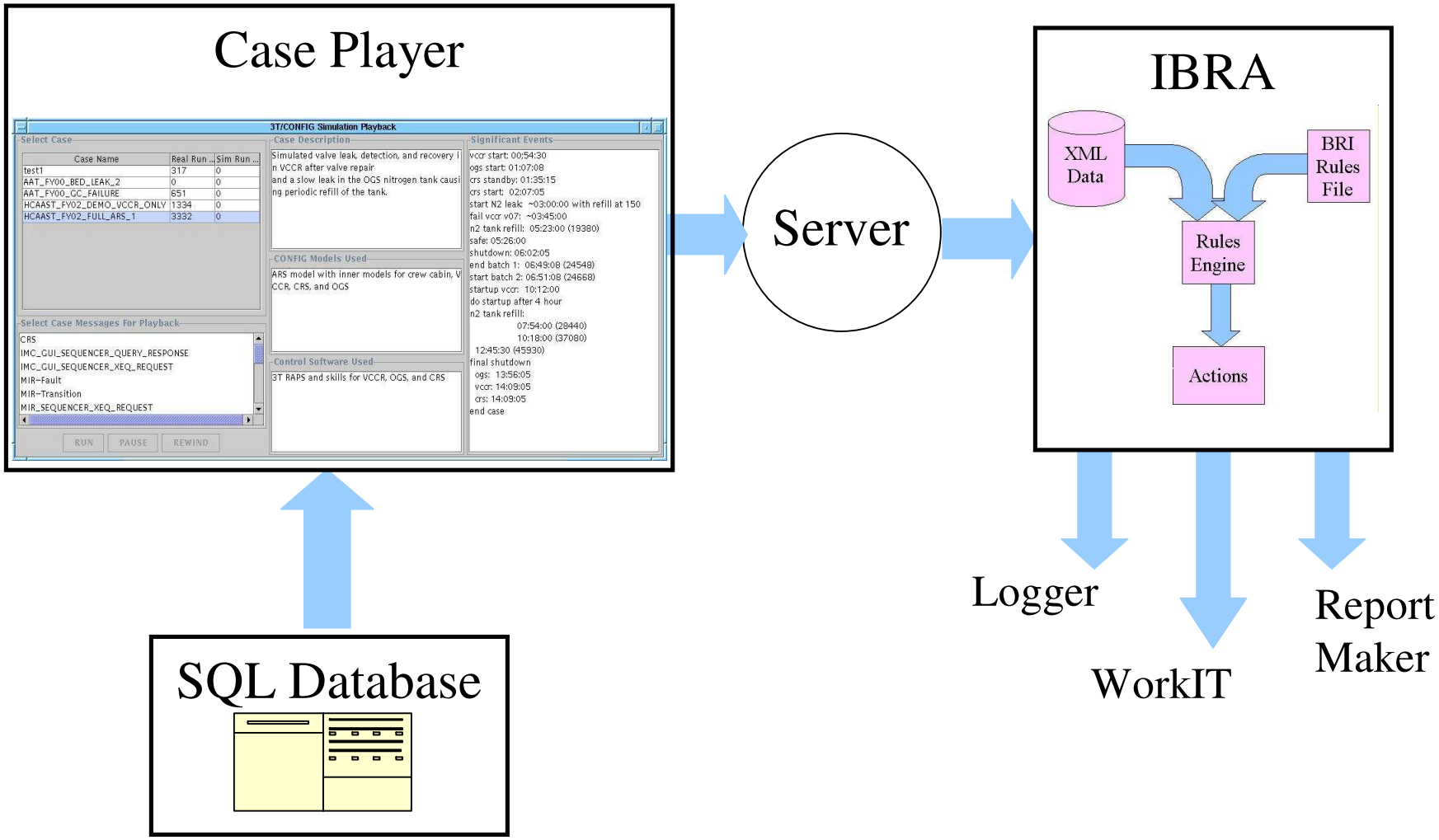
FY02 Task Areas

- Testbed for autonomous control agent
- Agent information and control
- Information handling tools and infrastructure for agent communication and control
- Human-centered methods for designer-developer teams

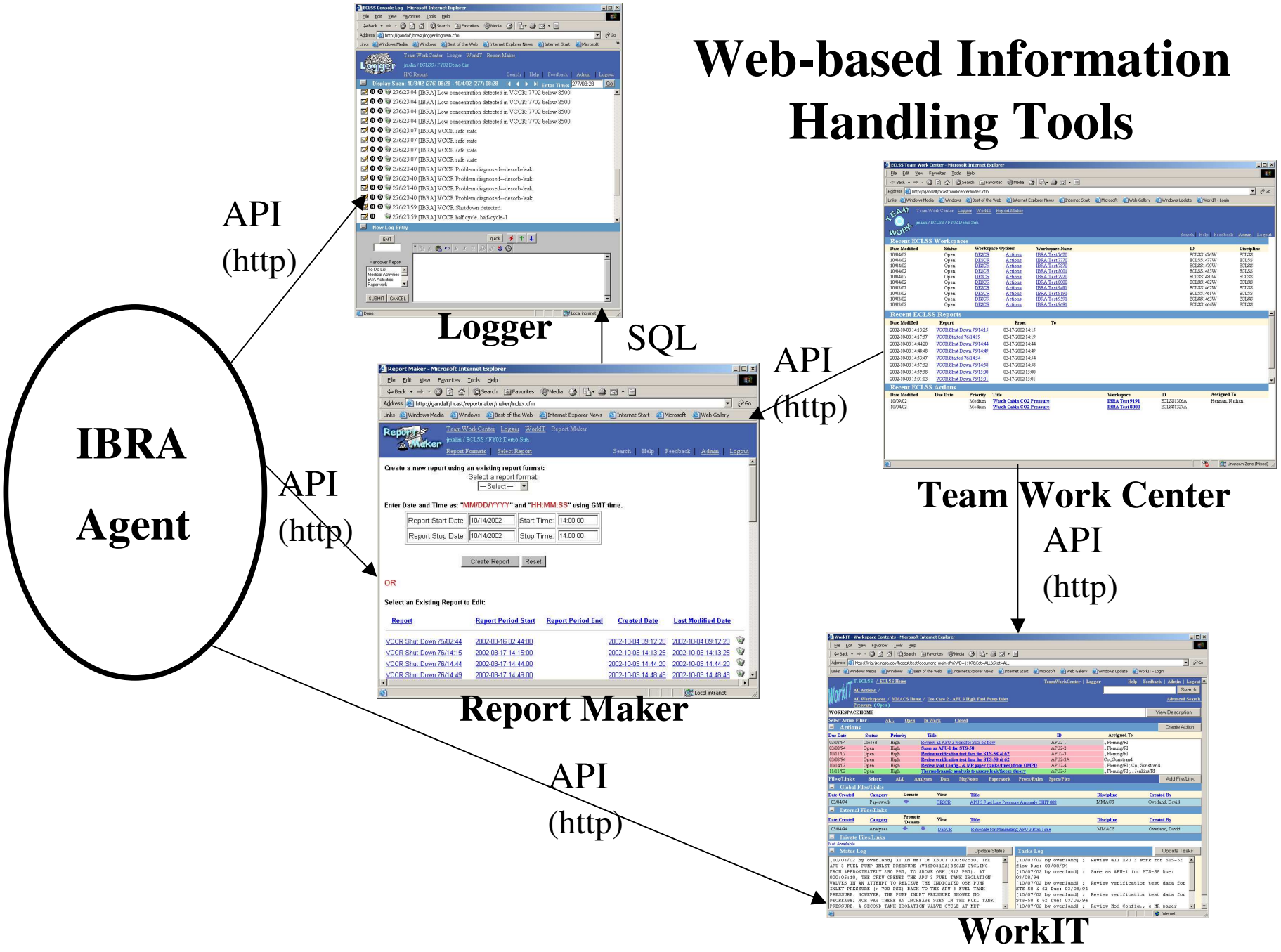
Testbed Architecture: ISMA, Simulation, Case Server Recording a Case for Playback



Testbed Architecture: Life Support Control Scenarios
Playing Back a Case



Web-based Information Handling Tools



Instructions for Intelligent Briefing and Response Assistants

- Inspired by mission operations Anomaly Response Instructions (ARIs)
  - For Station Duty Officers (SDOs) before the Space Station was manned
  - Filter, organize and distribute information on system status and anomaly response

ECLSS01 - NODE 1 RAPID DEPRESS

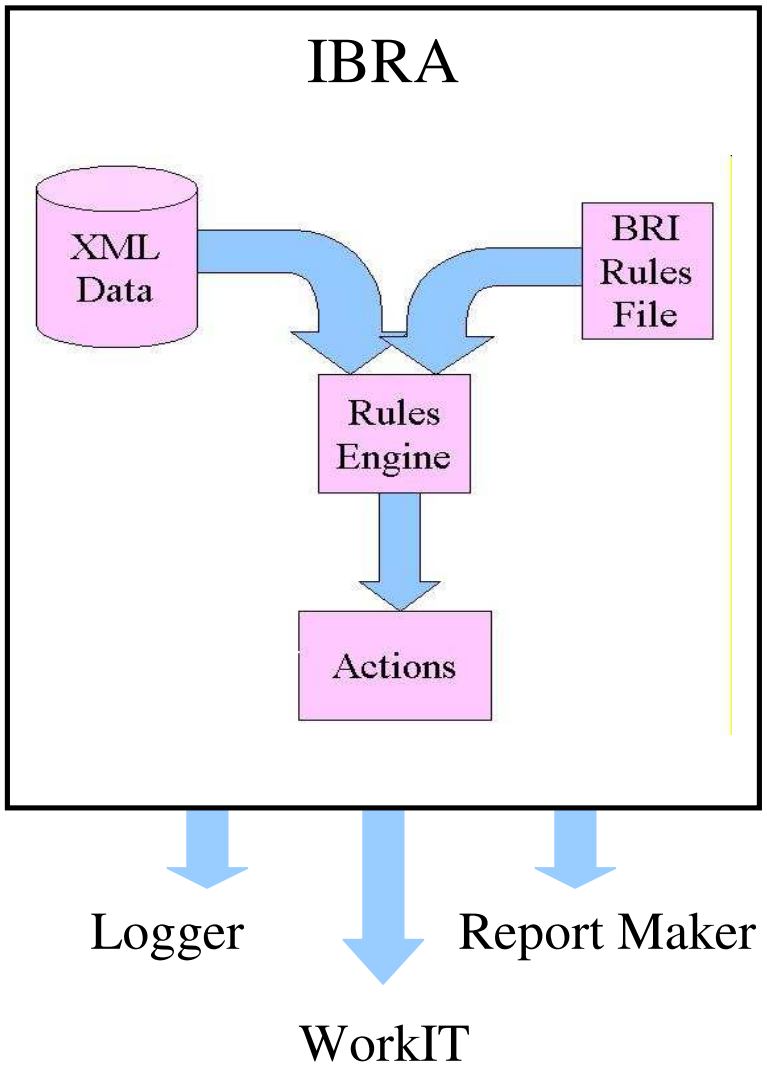
PURPOSE: To provide the SDO required actions upon receiving the ECLSS01 - Node 1 Rapid Depress ELOG Message

BACKGROUND: There is no onboard calculation of Node 1 rapid depressurization. A ground comp is used to calculate the Node pressure decay rate. The comp is susceptible to giving false readings if there are data interruptions or if there is a cabin pressure sensor bias or failure.

PROCEDURE

1. From the SDO display, record Node 1 cabin pressure.
2. From the SDO display, record Node 1 dPdt.
3. From the ECLSS SDO RTPLOT, check Node 1 pressure decreasing. Record slope, then multiply by 60 to get mm/hr.
4. If, after 30 minutes, there is a decrease in Node 1 Cabin pressure, call ECLSS, HSG, CATO, and Flight.

Briefing and Response Instructions



- Recognize complex patterns in input data
  - Use XML as the common data format
- Trigger actions in response to those patterns
  - Uses existing rule-based engine
  - Invoke user's tools
- BRI rules
  - Easily generated and modified
  - Flexible and powerful

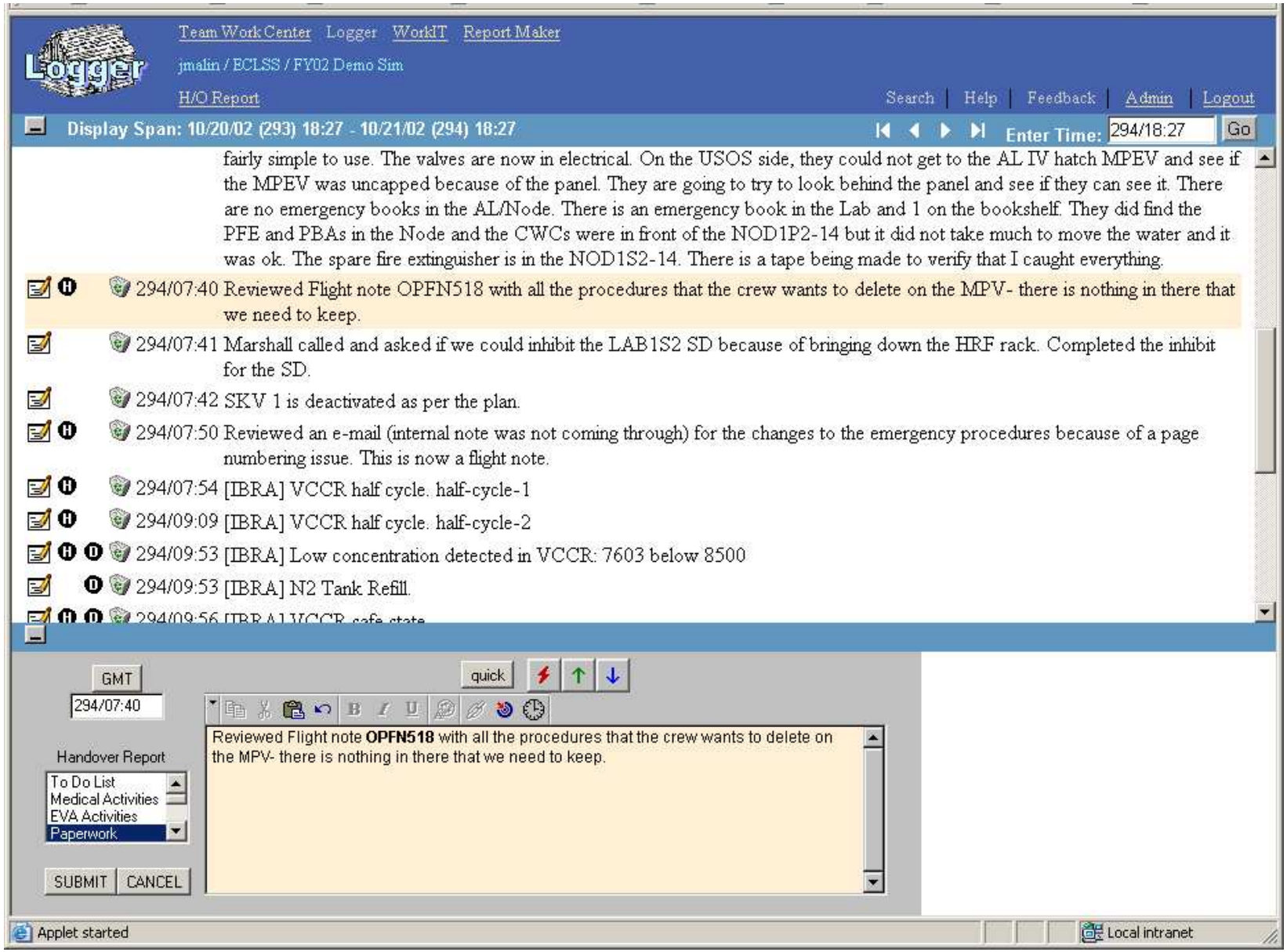
Example Briefing and Response Instruction Code

```
<lml:rule name="co2_conc_accum_low">
    <lml:lhs>
        <Activity>?a</Activity>
        <new-value>
            <time> ?t&(?t>1) </time>
            <variable>'co2-concentration_hc_tank'</variable>
            <value> ?v&(?v<8500)</value>
        </new-value>
    </lml:lhs>
    <lml:actions>
        <elogger>
            <attr name="loggerURLString“
              value="http://gandalf/hcast/logger/insert_into_log.cfm" />
            <attr name="loggeragent" value="IBRA" />
            <attr name="loggertimestamp" value="?t" />
            <attr name="loggerlog_text"
              value="[IBRA] Low concentration detected in VCCR: ?v below 8500" />
        </elogger>
    </lml:actions>
</lml:rule>
```

If CO_2 concentration < 8500

Make log entry

Logger: Log entries with metadata



Taking Advantage of ISMA High Level Information

- Intelligent System Management Agents support routine system management, assessment and safing
  - Not only monitor, detect and respond (e.g., safe the system), but also assess and plan
  - Use high level assessment, planning and procedure information to support supervision and anomaly response
    - New levels of intervention in procedures or plans?
    - New types of information about systems and ISMAs
      - Conveyed to team members by IBRAs using tools

IBRA-Generated Event Report with ISMA Information (Print Version)

VCCR Shut Down

Report generated 295/15:09

Author

IBRA Instruction VCCR_Shutdown

Trigger Value

VCCR Shutdown

Cause of Shutdown

Bed 3 leak

Time of shutdown

295/07:18

Procedure

PERFORM-CO2-DIAGNOSTICS

FIX-VCCR-PROBLEM-AMBIGUOUS-STATE

MONITOR-ARS

Result

DIAGNOSTIC-PERFORMED GC-DEGRADED

Evidence of problem **[plot]**

Action taken

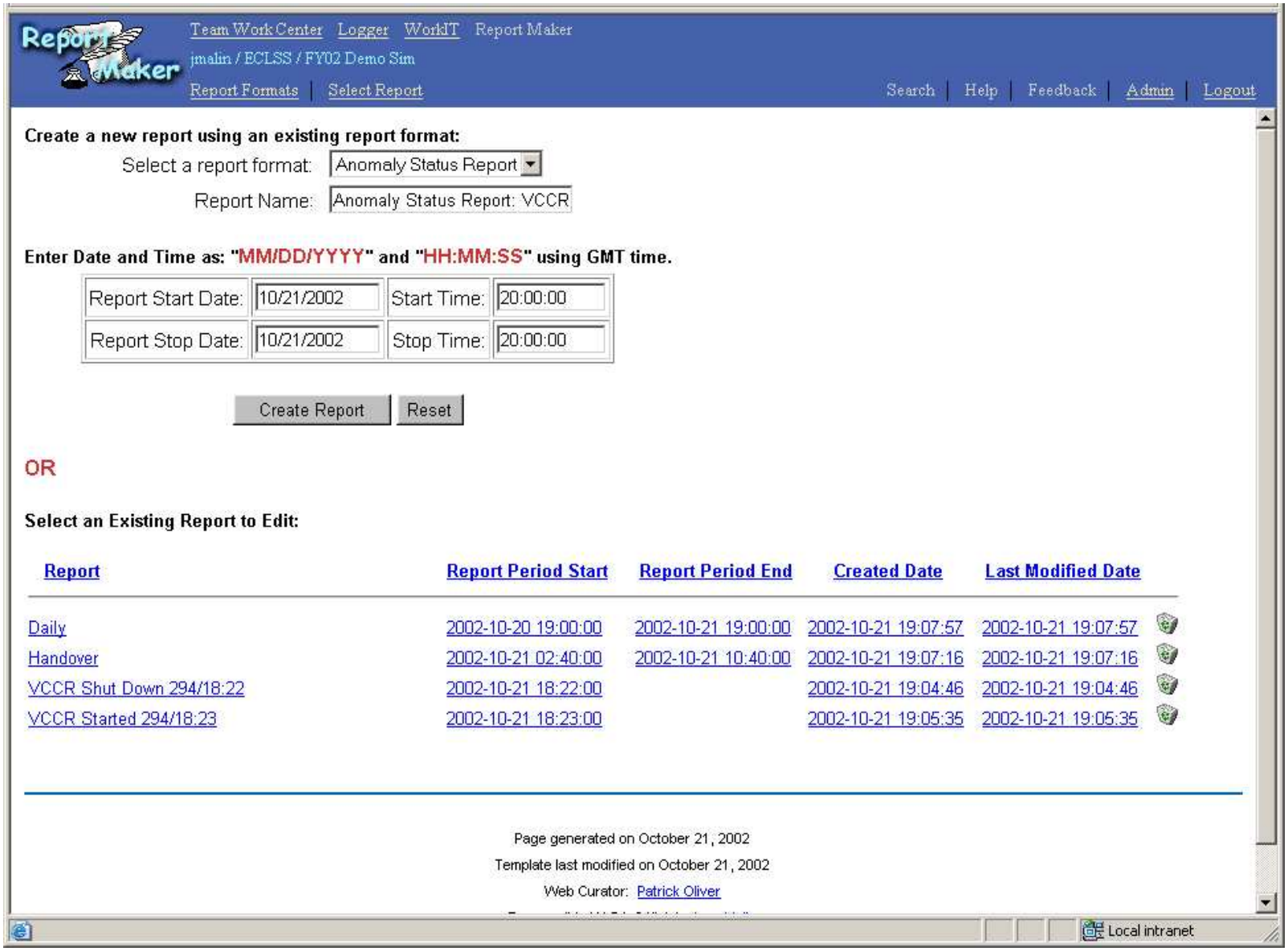
Maintenance entered in crew schedule

Caution

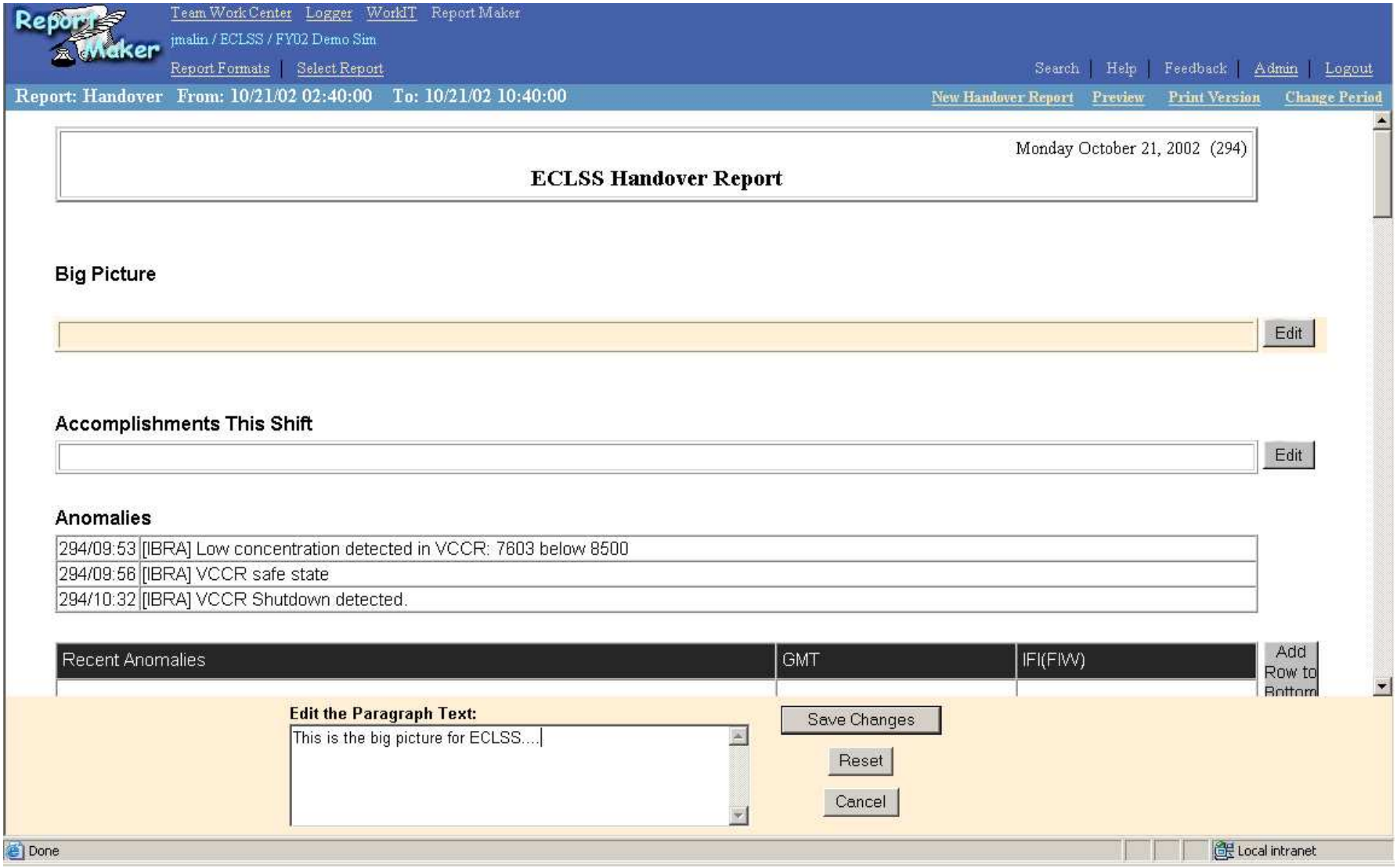
Watch cabin CO2 concentration for health risk to crew **[Text added by ECLSS in IBRA instruction]**

Comments

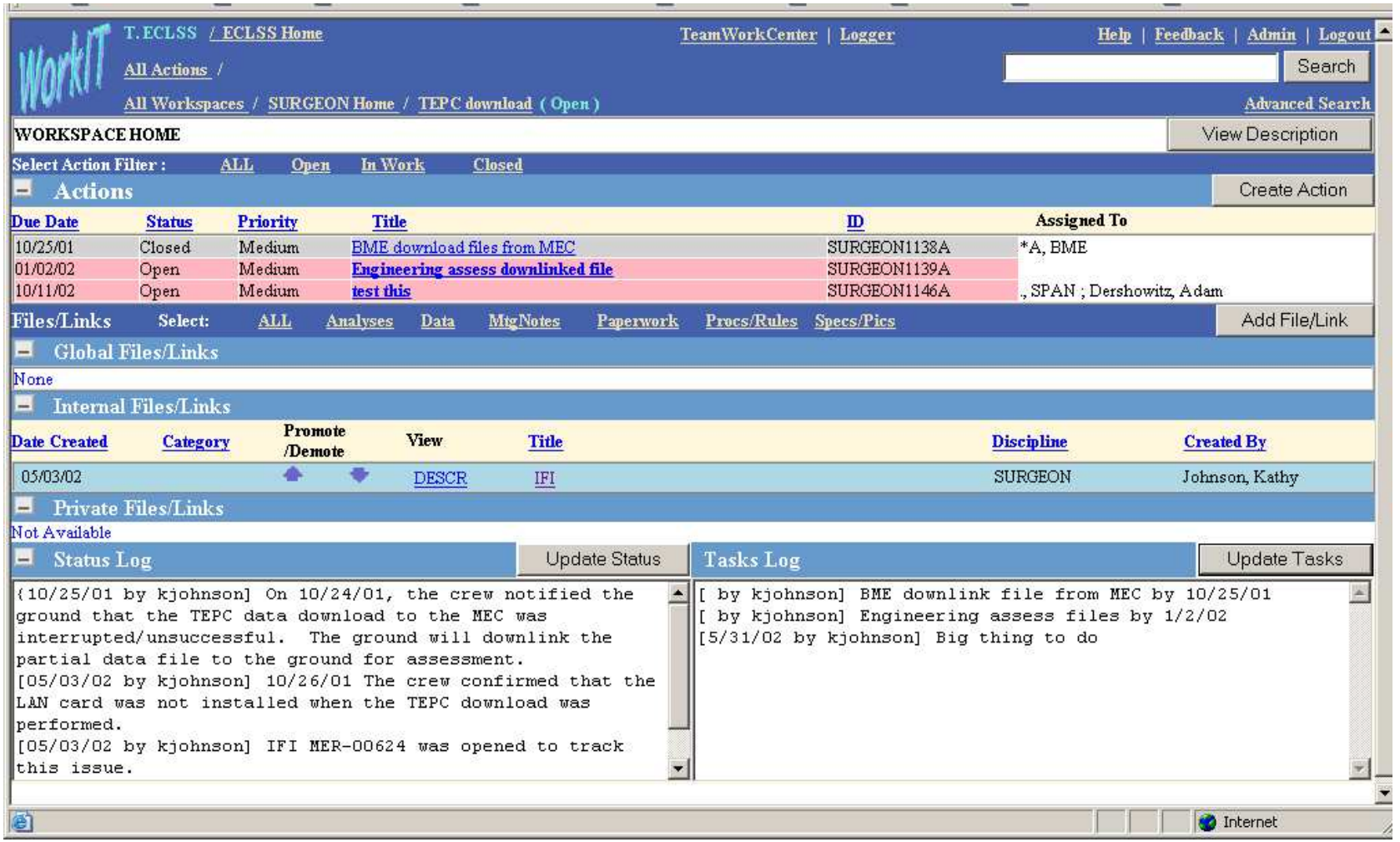
Report Maker: Create and Use Editable Report Formats



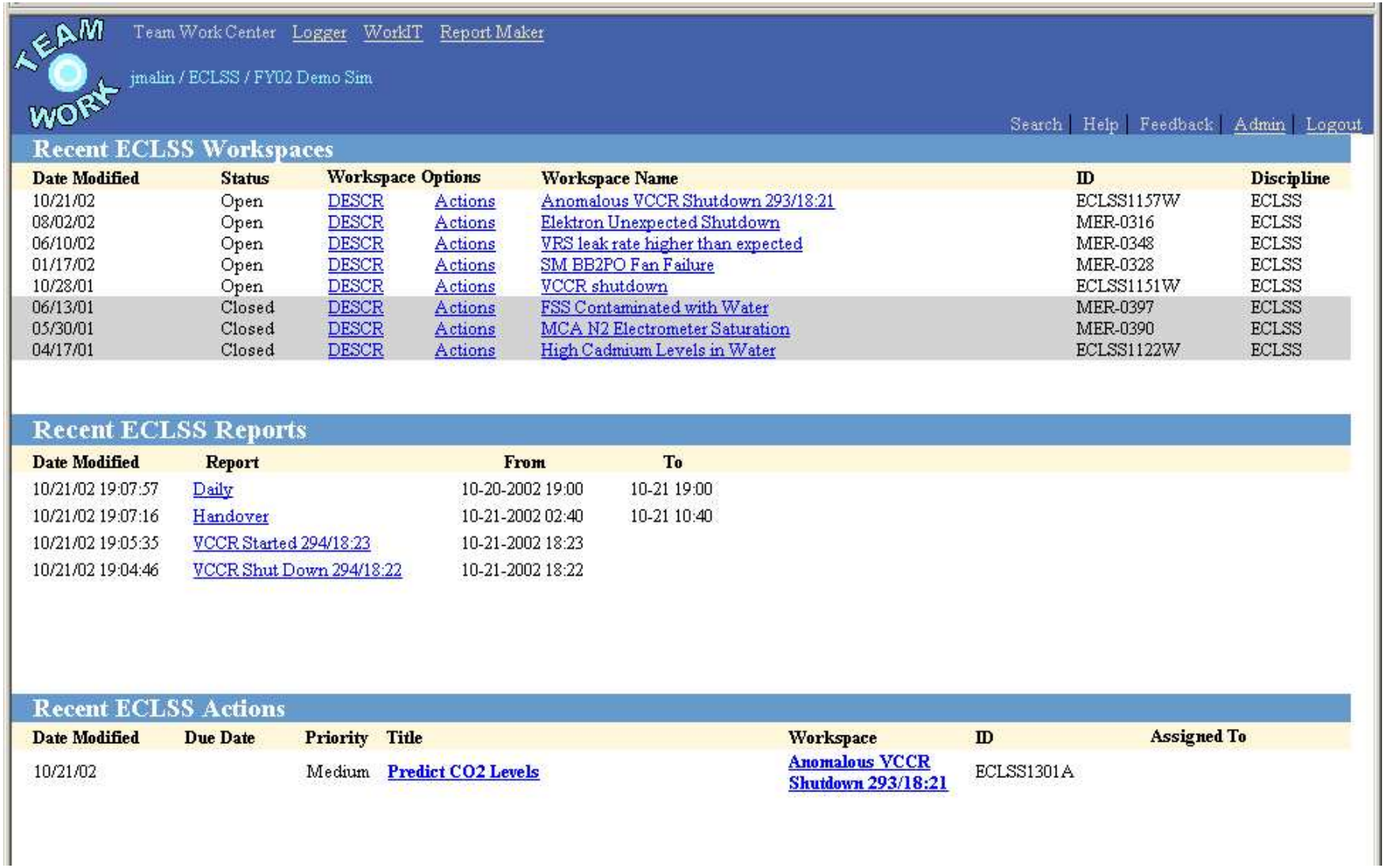
Example Handover Report (Editable Format)



WorkIT: Organized and searchable Issue Workspaces with Actions, Reference materials, Status of tasks and issues



Team Work Center: Portal into Tools and Recent Work of Flight Discipline



Team Work Center | Logger | WorkIT | Report Maker

jmalin / ECLSS / FY02 Demo Sim

Search | Help | Feedback | Admin | Logout

Recent ECLSS Workspaces

Date Modified	Status	Workspace Options		Workspace Name	ID	Discipline
10/21/02	Open	DESCR	Actions	Anomalous VCCR Shutdown 293/18:21	ECLSS1157W	ECLSS
08/02/02	Open	DESCR	Actions	Elektron Unexpected Shutdown	MER-0316	ECLSS
06/10/02	Open	DESCR	Actions	VRS leak rate higher than expected	MER-0348	ECLSS
01/17/02	Open	DESCR	Actions	SM BB2PO Fan Failure	MER-0328	ECLSS
10/28/01	Open	DESCR	Actions	VCCR shutdown	ECLSS1151W	ECLSS
06/13/01	Closed	DESCR	Actions	FSS Contaminated with Water	MER-0397	ECLSS
05/30/01	Closed	DESCR	Actions	MCA N2 Electrometer Saturation	MER-0390	ECLSS
04/17/01	Closed	DESCR	Actions	High Cadmium Levels in Water	ECLSS1122W	ECLSS

Recent ECLSS Reports

Date Modified	Report	From	To
10/21/02 19:07:57	Daily	10-20-2002 19:00	10-21 19:00
10/21/02 19:07:16	Handover	10-21-2002 02:40	10-21 10:40
10/21/02 19:05:35	VCCR Started 294/18:23	10-21-2002 18:23	
10/21/02 19:04:46	VCCR Shut Down 294/18:22	10-21-2002 18:22	

Recent ECLSS Actions

Date Modified	Due Date	Priority	Title	Workspace	ID	Assigned To
10/21/02		Medium	Predict CO2 Levels	Anomalous VCCR Shutdown 293/18:21	ECLSS1301A	

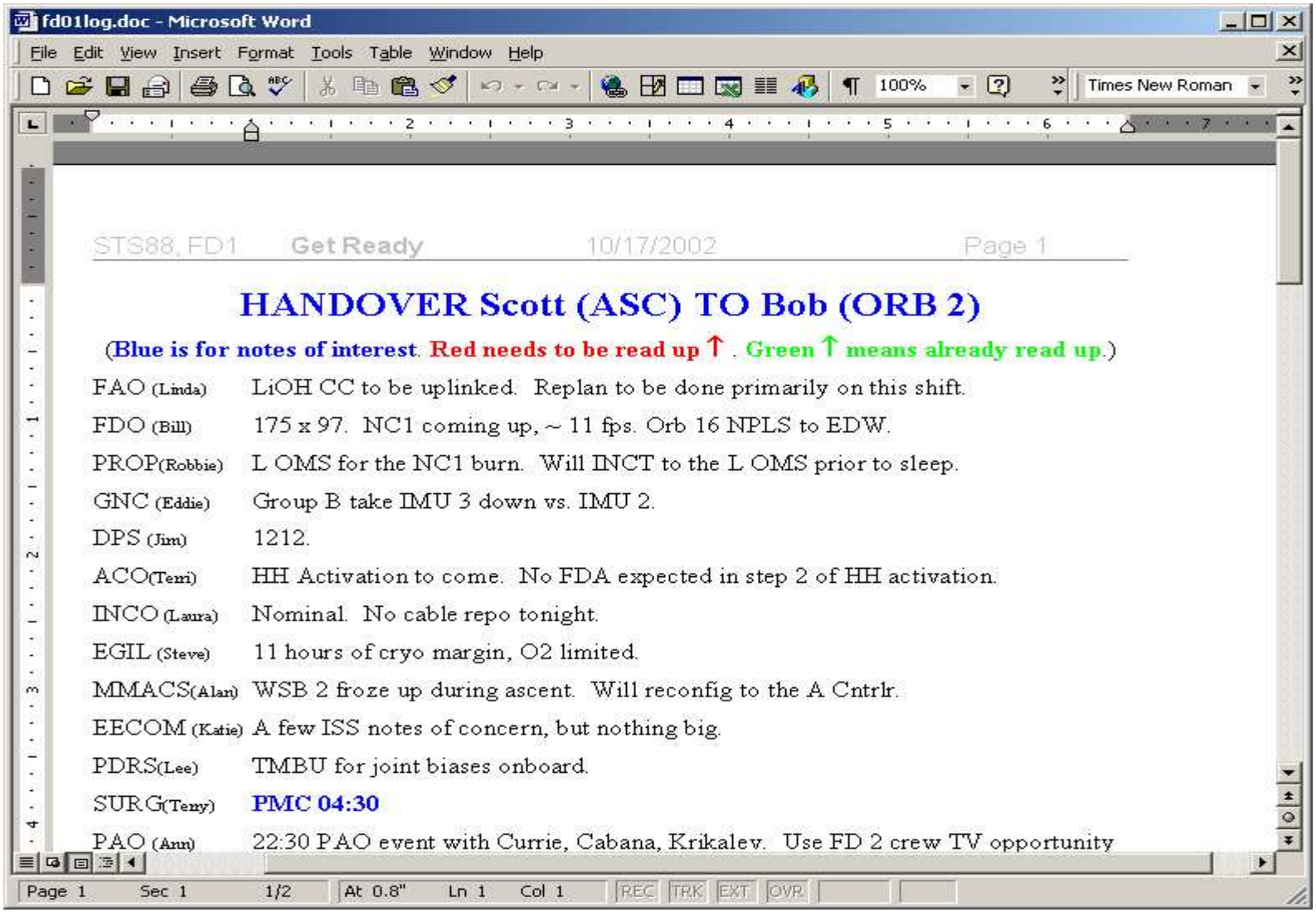
Human-Centered Methods for Development Teams

- Process and products for rapid prototyping teams
  - Designers, developers, users
  - Boundary objects for human-centered teams
    - Shared objects to talk about, think with, coordinate perspectives of constituencies (G. Fischer)
- Two different types of designer-developer teams
  - Electronic Console Logger and Report Maker
    - Tight team integration, one of developers is past user
  - WorkIT Evaluation and Enhancement
    - Loose team integration (separate organization), developer is not past user

HCS Evaluation Products

- Formative evaluation of prototype
  - Not just “How well did we do?”
  - What improvements and new capabilities are needed?
- Throughout Phases
  - Phase 1: Analysis Phase
  - Phase 2: Development Phase
  - Phase 3: Assessment and Refinement Phase
- Using Boundary Objects: Artifacts, use cases, annotated screen shots, annotated sketches

CAPCOM Log Artifact



fd01log.doc - Microsoft Word

File Edit View Insert Format Tools Table Window Help

Times New Roman

STS88, FD1 Get Ready 10/17/2002 Page 1

HANDOVER Scott (ASC) TO Bob (ORB 2)

(**Blue is for notes of interest. Red needs to be read up ↑ . Green ↑ means already read up.**)

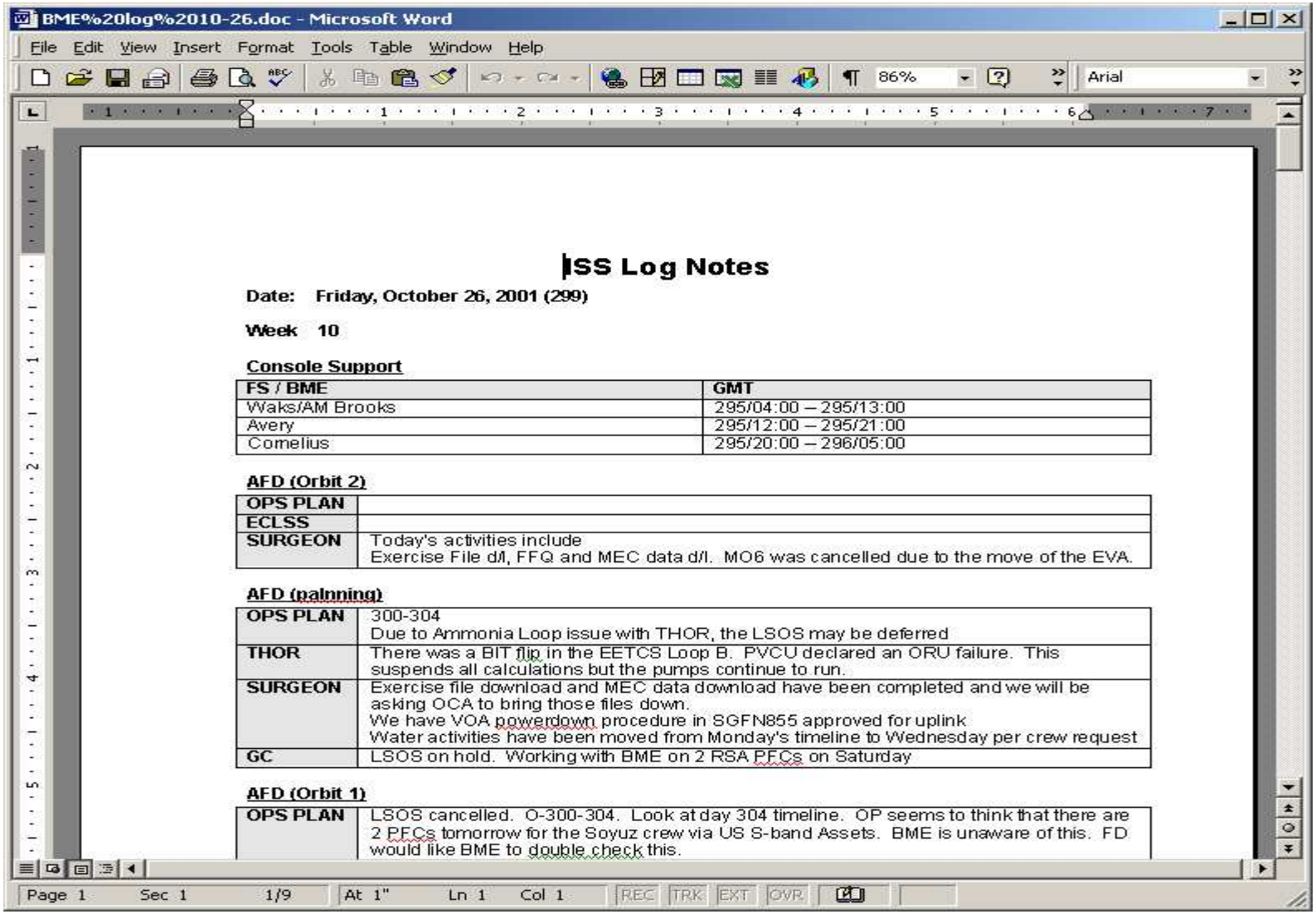
FAO (Linda)	LiOH CC to be uplinked. Replan to be done primarily on this shift.
FDO (Bill)	175 x 97. NC1 coming up, ~ 11 fps. Orb 16 NPLS to EDW.
PROP(Robbie)	L OMS for the NC1 burn. Will INCT to the L OMS prior to sleep.
GNC (Eddie)	Group B take IMU 3 down vs. IMU 2.
DPS (Jim)	1212.
ACO(Teri)	HH Activation to come. No FDA expected in step 2 of HH activation.
INCO (Laura)	Nominal. No cable repo tonight.
EGIL (Steve)	11 hours of cryo margin, O2 limited.
MMACS(Alan)	WSB 2 froze up during ascent. Will reconfig to the A Cntrlr.
EECOM (Katie)	A few ISS notes of concern, but nothing big.
PDRS(Lee)	TMBU for joint biases onboard.
SURG(Teny)	**PMC 04:30**
PAO (Ann)	22:30 PAO event with Currie, Cabana, Krikalev. Use FD 2 crew TV opportunity

Page 1 Sec 1 1/2 At 0.8" Ln 1 Col 1 REC TRK EXT OVR

Analysis Phase

- Goal: Gain enough understanding of the user task to design the first approximation to supporting it
- Initial interview(s) with the user to obtain
  - Use Case Scenarios
  - Artifacts – what is used and produced to meet task demands now?
  - Characteristics of team tasks and communication
  - Review of possible support strategies (partial designs)

BME Log Artifact



ISS Log Notes

Date: Friday, October 26, 2001 (299)

Week 10

Console Support

FS / BME	GMT
Waks/AM Brooks	295/04:00 – 295/13:00
Avery	295/12:00 – 295/21:00
Cornelius	295/20:00 – 296/05:00

AFD (Orbit 2)

OPS PLAN	
ECLSS	
SURGEON	Today's activities include Exercise File d/l, FFQ and MEC data d/l. MO6 was cancelled due to the move of the EVA.

AFD (palnning)

OPS PLAN	300-304 Due to Ammonia Loop issue with THOR, the LSOS may be deferred
THOR	There was a BIT flip in the EETCS Loop B. PVCU declared an ORU failure. This suspends all calculations but the pumps continue to run.
SURGEON	Exercise file download and MEC data download have been completed and we will be asking OCA to bring those files down. We have VOA powerdown procedure in SGFN855 approved for uplink Water activities have been moved from Monday's timeline to Wednesday per crew request
GC	LSOS on hold. Working with BME on 2 RSA PFCs on Saturday

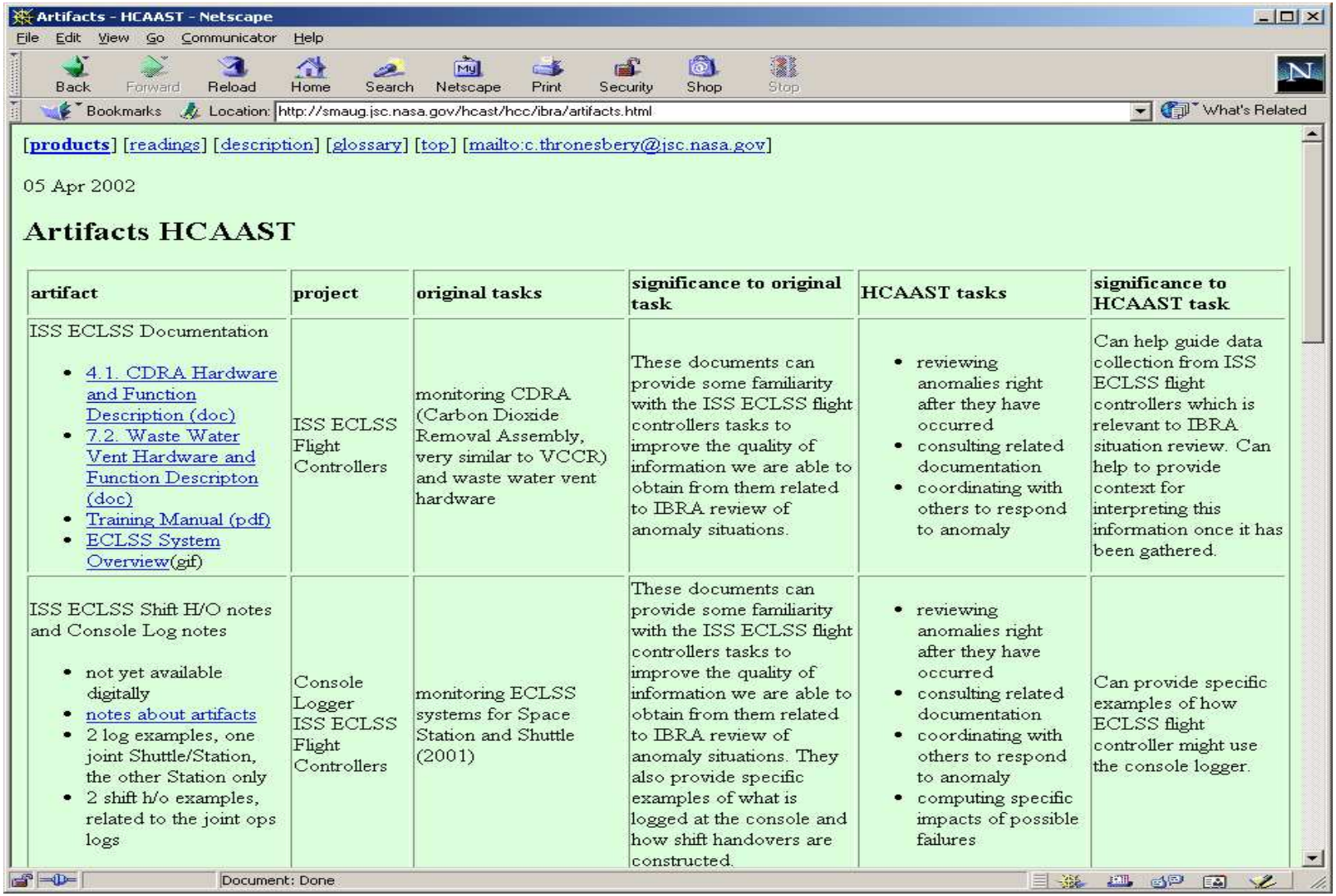
AFD (Orbit 1)

OPS PLAN	LSOS cancelled. O-300-304. Look at day 304 timeline. OP seems to think that there are 2 PFCs tomorrow for the Soyuz crew via US S-band Assets. BME is unaware of this. FD would like BME to double check this.

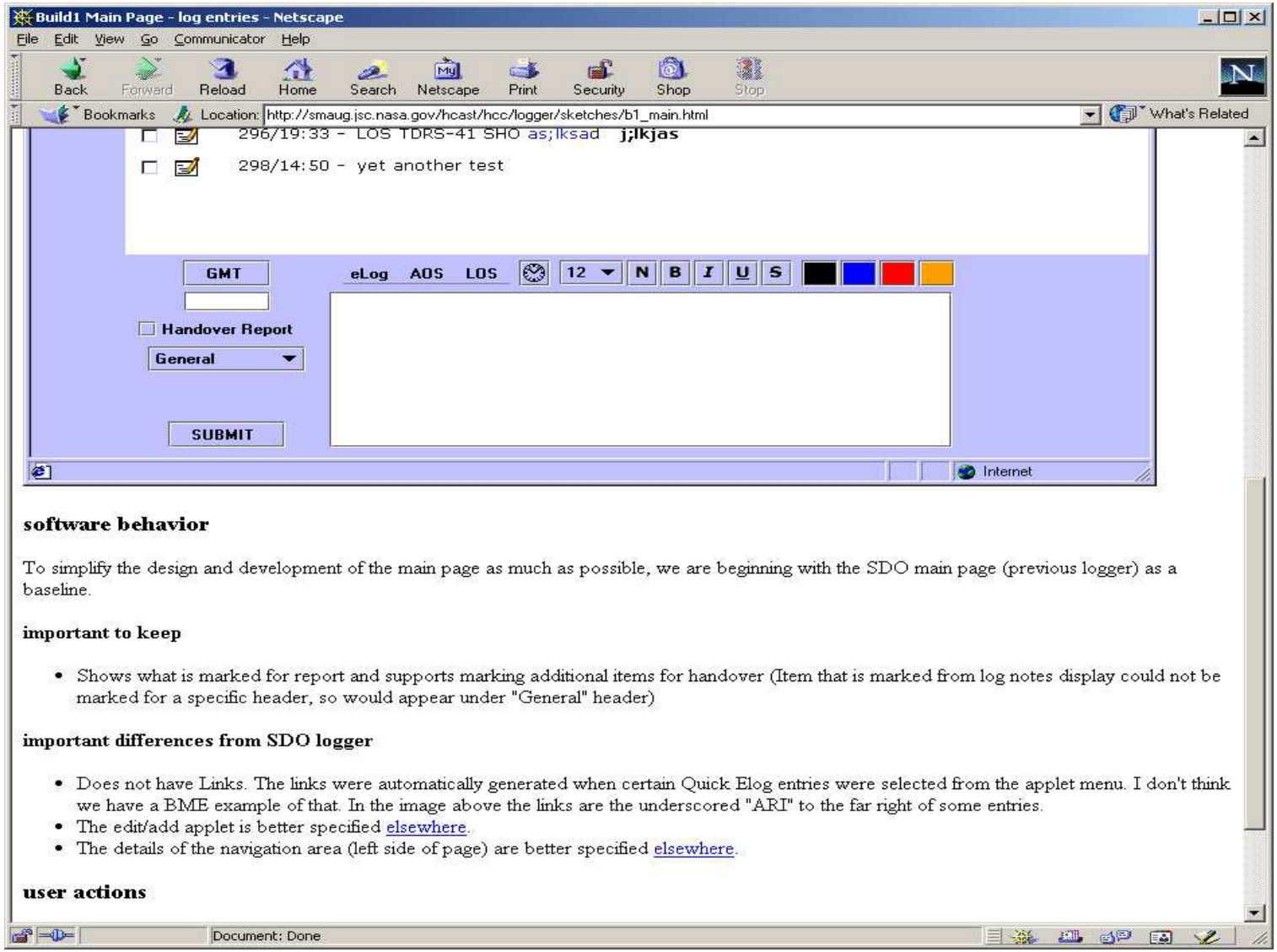
Prototype Development Phase

- Steer the implementation to support design intention
  - Spiral development
    - Reevaluation and planning as each core function is developed
    - Controlled requirements creep (no loss of focus)
  - Continual feedback between designers and developers
    - Analyze design decisions that make implementation difficult
    - Find efficient design alternatives that fit design intentions
  - Communication formats
    - Design support: Boundary objects (artifacts, annotated sketches and snapshots, partial prototypes)
    - Management support: WorkIT actions to track development tasks

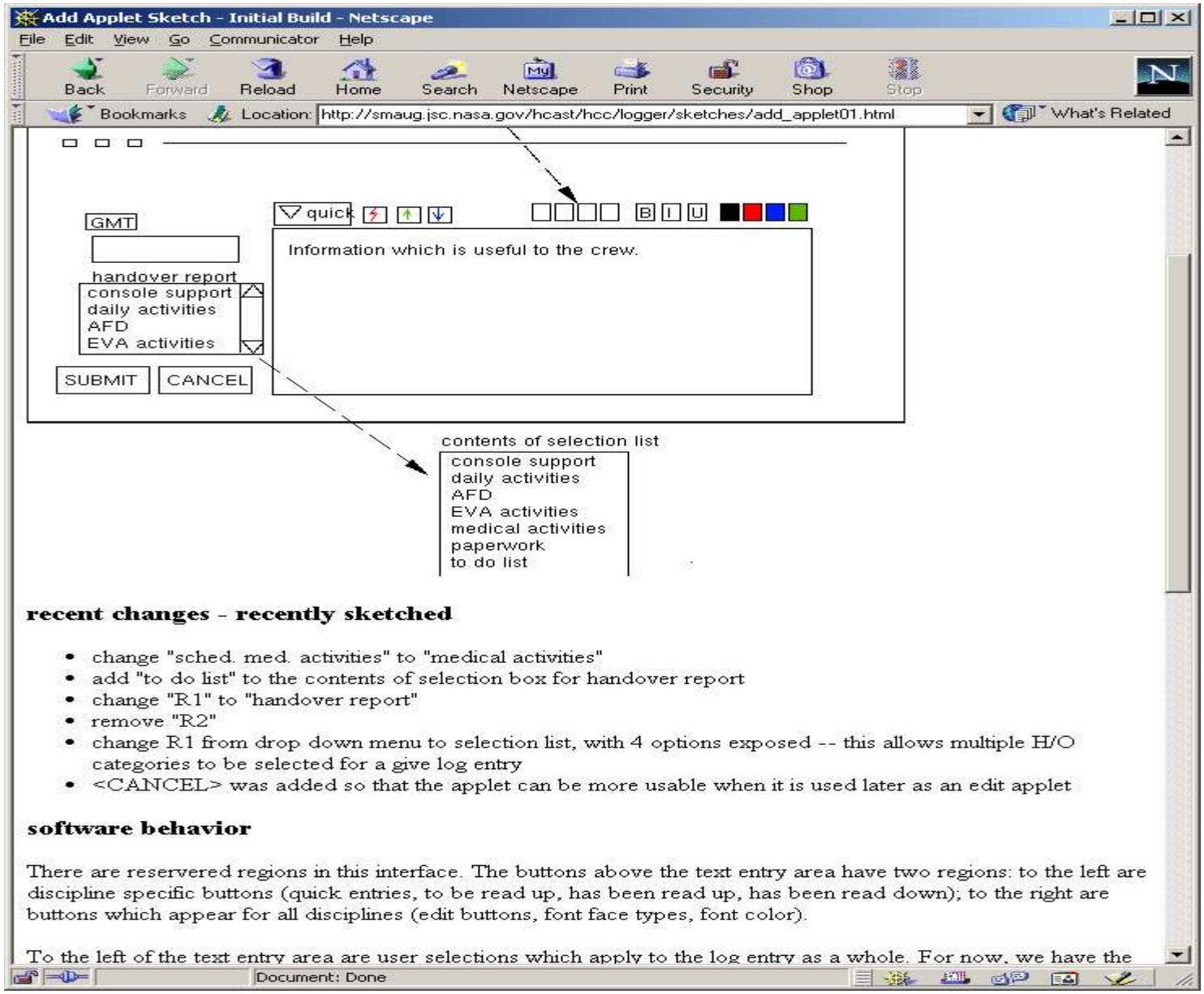
Developers Links to Artifacts



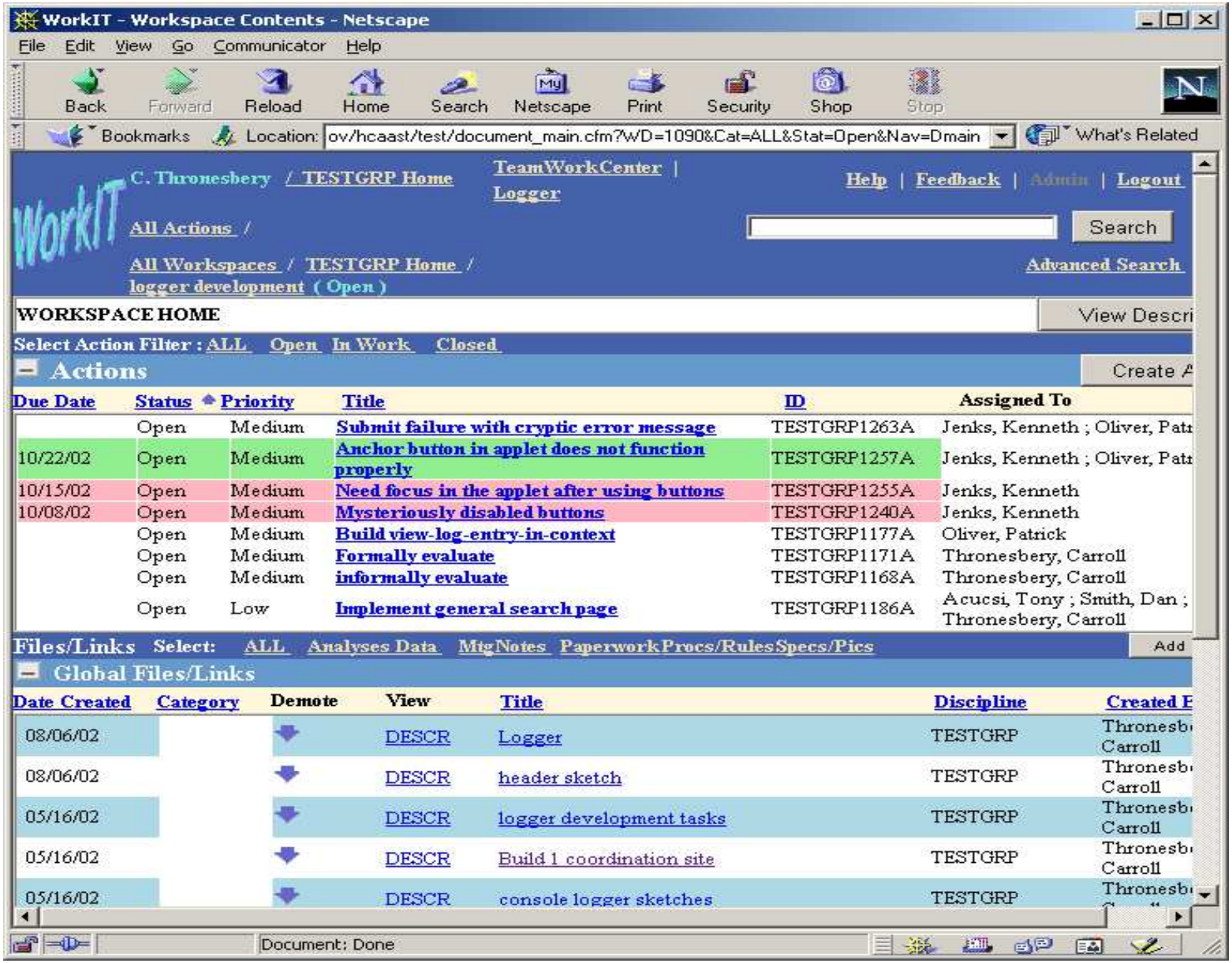
Annotated Screen Snaphot



Annotated Sketch



WorkIT Actions: Track Problems



Assessment and Refinement Phase

- Use case test by designers
  - Can designers perform user tasks as expected?
  - Reproducing artifacts keeps evaluation focused on user tasks
- Initial evaluation – user performs basic tasks
  - Address 3 Us (understanding, usefulness, usability)
  - Use case scenarios keep evaluation focused on the tasks
- Take home and use – expose deeper level issues
  - Identify hidden tasks and persistent difficulties
- Interviews and focus groups after take-home use
  - Explore specific evaluation objectives and issues
  - Review designs for next prototype iteration, with boundary objects

Important Human-Centered Practices

- Focus on designer ←→ developer interactions
  - Support prototyping without firm requirements
    - Support redesign and detailed design that balances design intentions and implementation concerns
- Useful boundary objects "common language"
  - Used by multiple groups in multiple development phases
    - Each group can interpret object's implications for their interests
  - Representing general cases with implications for design
    - With annotations, objects can represent task characteristics, design intent, design implications
  - Concrete – for specific communication
    - Each group can point at the object for common reference

FY02 Demonstration

- ISMA manages air processing systems as specified
  - Reports status and operations of simulated system
  - Makes anticipated response to handle system problem (leak)
- IBRA manages information from ISMA according to team instructions
  - When triggered, makes log entries, constructs event reports, and uses a workspace
- Flight Controllers periodically review information and handle system problems
  - Supported by tools containing ISMA-IBRA information and information from the ECLSS team

Mission Spin-offs

- SMART project: Issue Tracking support for Space Station BME/Surgeon discipline
  - WorkIT prototype evaluated, enhanced, ready for conversion to BME use in missions, for further evaluation and enhancement.
    - User organization will provide funds
  - Prototype will be enhanced for use by other disciplines, starting with ECLSS
- Logger, Report Maker and Team Work Center prototypes are ready for BME evaluation

Benefits of Cooperating Intelligent Agents

- Freedom from some system management tasks
  - ISMA autonomous system control
- Flexibility in directing and changing agent services
  - ISMA adjustable agent with replanning
  - IBRA instructions from users
- Improved understanding and information handling while busy with other tasks
  - ISMA high level event information
  - IBRA log entries, situation reports and analyses
  - Team Work Center tools for information organization and asynchronous communication
  - Addresses today's problems: too many interruptions, hard to find pertinent information from earlier episodes, hard to reuse information

FY03 Plans

- Develop tool for specifying IBRA instructions
- Develop concepts for team-to-agent coordination and communication during anomalies
  - Identify needed agent enhancements
- Advance tools and agent-tools architecture
- Advance and refine human-centered methods
  - Investigate incremental requirements development during rapid prototyping, using boundary objects